New Digital Services from the BIPM

Digital Reference Point

SI

bipm.org/digital-transformation

Bureau International des Poids et Mesures

Dr Martin Milton

October 2023

27th meeting of the
General Conference of Weights and Measures (CGPM) in November 2022

https://www.bipm.org/en/committees/cg/cgpm

Resolution 2

"On the global digital transformation and International System of Units"

Encourages

the CIPM to undertake the development and promotion of an SI Digital Framework, that will include the following features:

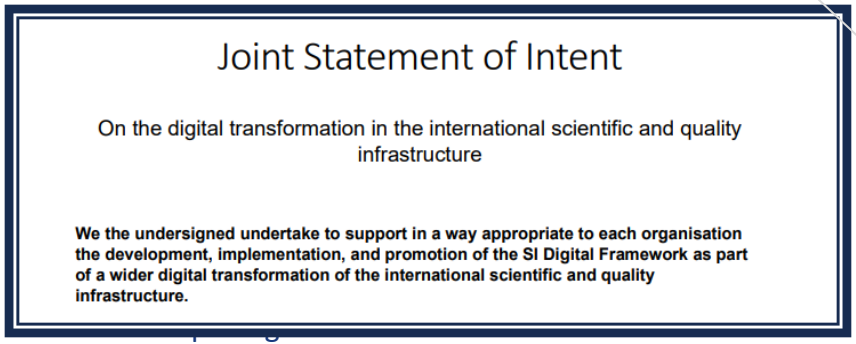
- a globally accepted digital representation of the SI, compatible with, and useable within, digital data exchange standards and protocols, whilst maintaining compatibility with existing non-digital solutions,
- facilitating use of digital certificates in the existing robust infrastructure for the world-wide recognition and acceptance of calibration and measurement capabilities,
- the adoption of the FAIR principles (Findable, Accessible, Interoperable, and Reusable) for digital metrological data and metadata, ensuring that other communities recognize the critical importance of metrological traceability for measurement data, the latter being an established requisite for building trust.

The Joint Statement

"On the digital transformation in the international scientific and quality infrastructure"

Digital Transformation

Joint Statement of Intent *On the digital transformation in the international scientific and quality infrastructure*



Joint Statement of Intent

On the digital transformation in the international scientific and quality infrastructure

We the undersigned undertake to support in a way appropriate to each organisation the development, implementation, and promotion of the SI Digital Framework as part of a wider digital transformation of the international scientific and quality infrastructure.

The SI Digital Framework provides a fully digital representation of the SI

- Provide the globally accepted anchor of trust for metrology in the digital era
- Facilitate the use of digital certificates and the adoption of the FAIR principles

The SI Digital Framework provides a fully digital representation of the SI

What are **digital references**?

- A persistent identifier (PI or PID) is a long-lasting reference to a document, file, web page, or other object.
- ….. you can plug it into a web browser and be taken to the identified source.

Barcodes

eg DOIs

Citation S M Judge *et al* 2023 *Metrologia* **60** 012001

DOI 10.1088/1681-7575/aca67a

10.1088/1681-7575/aca67a

QR codes

eg ORCID iDs

Olav Werhahn https://orcid.org/0000-0002-2317-3436

Chingis Kuanbayev https://orcid.org/0009-0004-0902-417X

0009-0004-0902-417X

The SI Digital Framework provides a fully digital representation of the SI

- Provide the globally accepted anchor of trust for metrology in the digital era
- Facilitate the use of digital certificates and the adoption of the FAIR principles

Services underpinning the SI digital framework

BIPM digital references

- SI Reference Point
- Measurement service categories
- Calibration and Measurement Capabilities (CMC)
- National Metrology Institutes
- Unit interoperability service

The SI Digital Framework provides a fully digital representation of the SI

- Provide the globally accepted anchor of trust for metrology in the digital era
- Facilitate the use of digital certificates and the adoption of the FAIR principles

Services underpinning the SI digital framework

BIPM digital references

- SI Reference Point
- Measurement service categories
- Calibration and Measurement Capabilities (CMC)
- National Metrology Institutes
- Unit interoperability service

External digital references

- ROR
- ORCID
- InChI

The SI Digital Framework provides a fully digital representation of the SI

- Provide the globally accepted anchor of trust for metrology in the digital era
- Facilitate the use of digital certificates and the adoption of the FAIR principles

Services underpinning the SI digital framework

BIPM digital references

- SI Reference Point
- Measurement service categories
- Calibration and Measurement Capabilities (CMC)
- National Metrology Institutes
- Unit interoperability service

External digital references

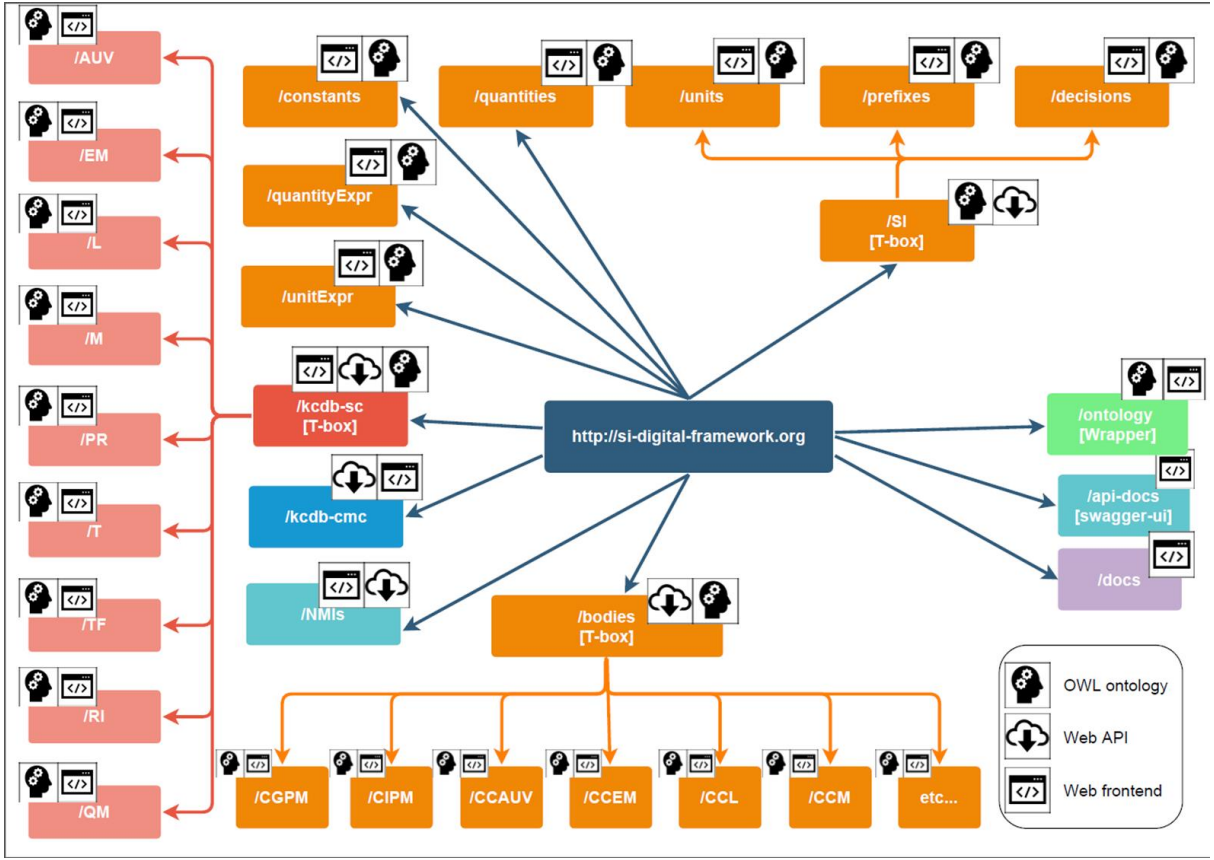
- ROR
- ORCID
- InChI

BIPM online databases

- Key Comparison Database - B
- Key Comparison Database - C
- UTC database

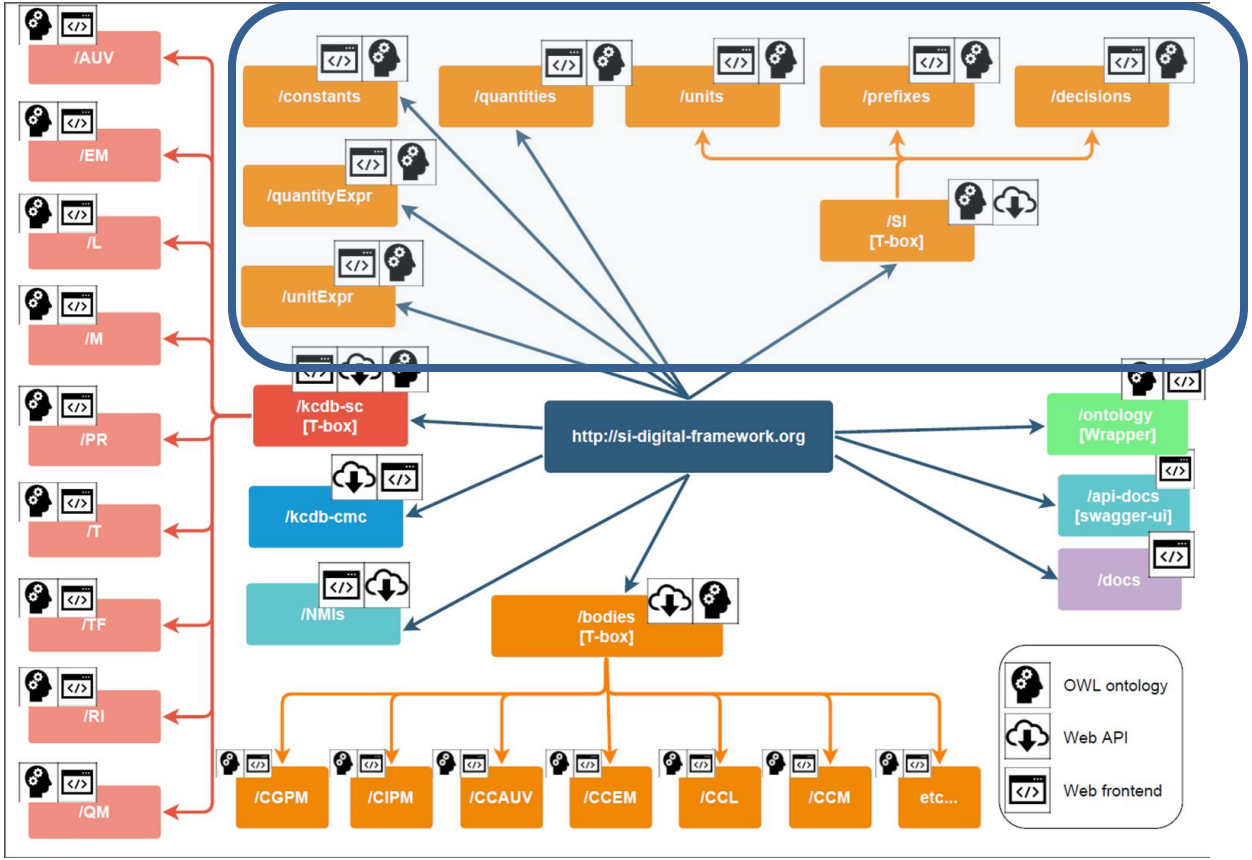
All human readable, through API, and machine readable using SPARQL queries

The SI Digital Framework provides a fully digital representation of the SI



- Standardized vocabularies
- Web services for software agents
- Web interfaces for humans
- Accessible through a coherent persistent identifier scheme

The SI Digital Framework provides a fully digital representation of the SI

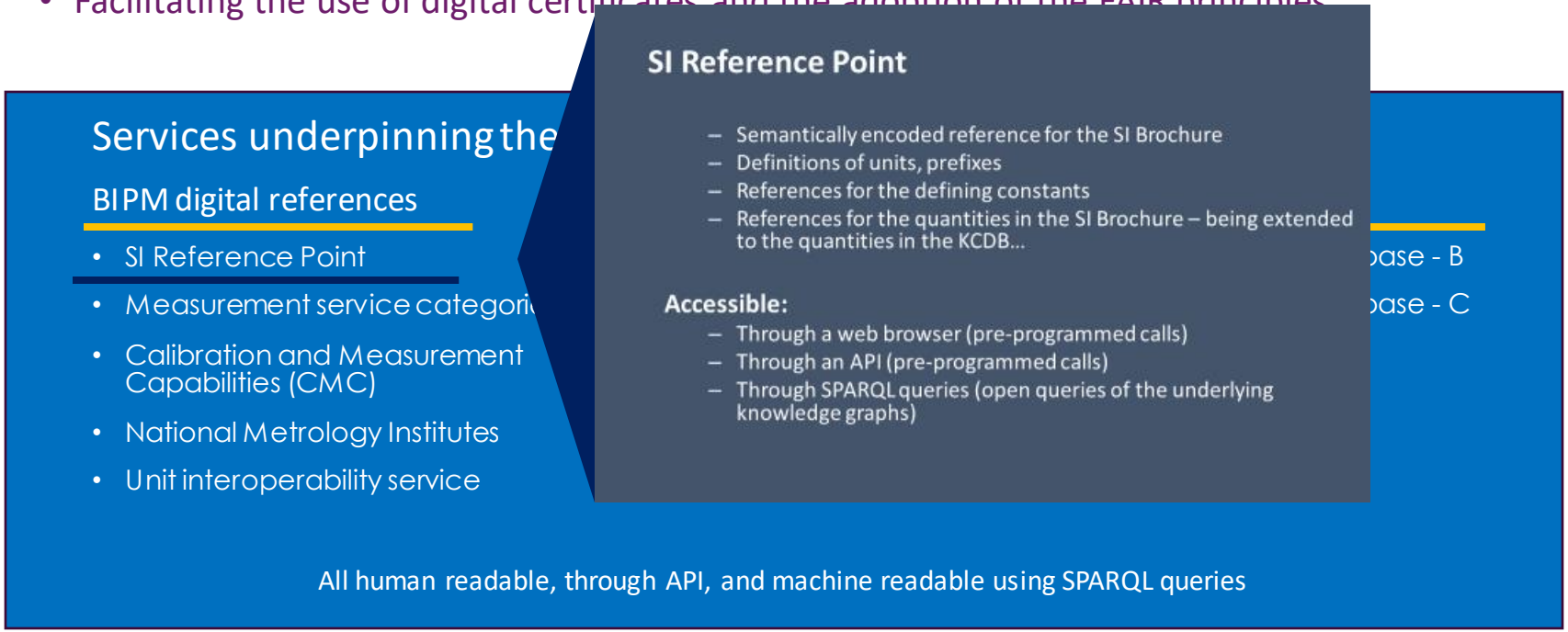


- Standardized vocabularies
- Web services for software agents
- Web interfaces for humans
- Accessible through a coherent persistent identifier scheme

10

The SI Digital Framework provides a fully digital representation of the SI

- Providing the globally accepted anchor of trust for metrology in the digital era
- Facilitating the use of digital certificates and the adoption of the FAIR principles



11

The SI Digital Framework provides a fully digital representation of the SI

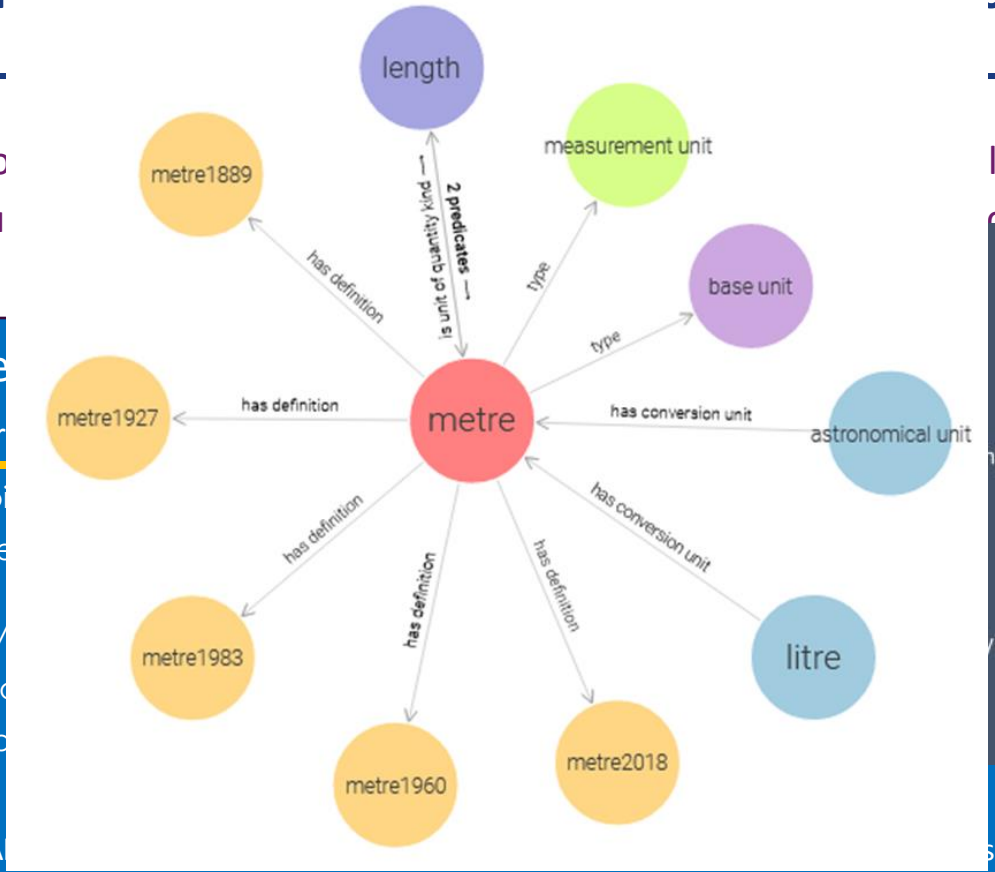
- Providing the glo … l era
- Facilitating the u … ciples

Services unde…

BIPM digital refer…

- SI Reference Poi…
- Measurement se…
- Calibration and … Capabilities (CM…
- National Metrol…
- Unit interoperab…

A… …s



SI REFERENCE POINT

English | Français

Version: 1.0, last update: 12/09/2023

metre

The metre, symbol m, is the SI unit of length. It is defined by taking the fixed numerical value of the speed of light in vacuum, c, to be $299\,792\,458$ when expressed in the unit $\mathrm{m\,s^{-1}}$, where the second is defined in terms of the caesium frequency $\Delta\nu_{\mathrm{Cs}}$.

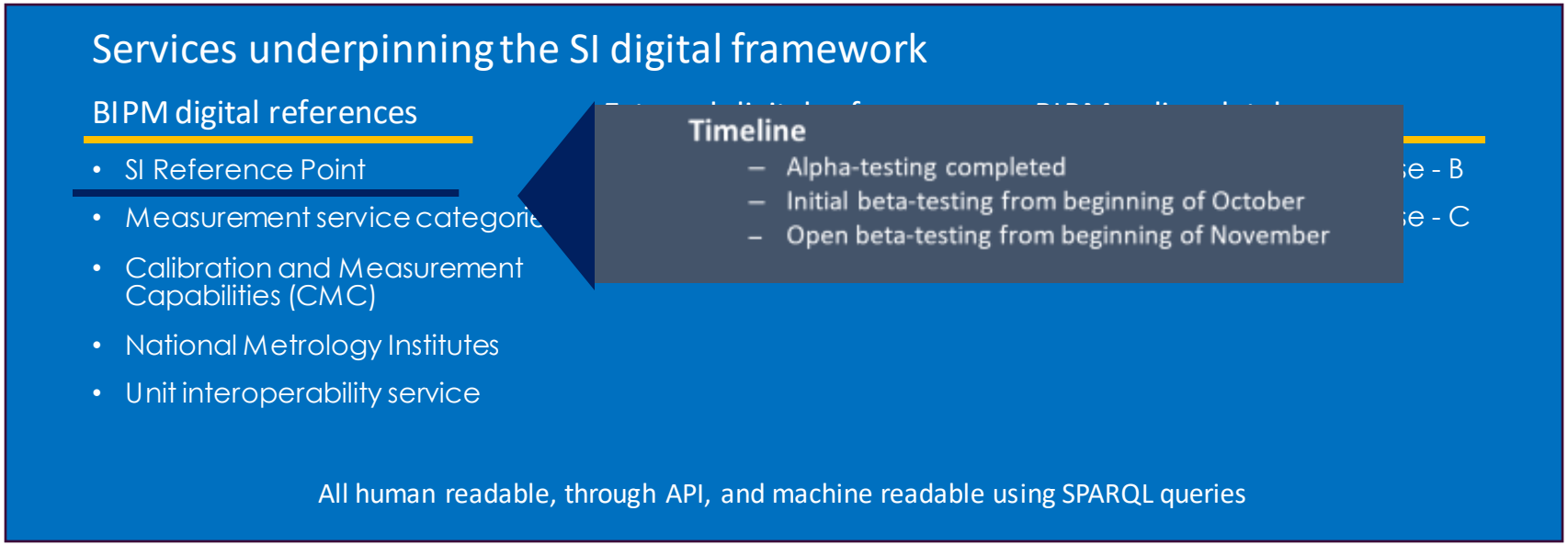
This definition is valid from 2019-05-20

‹ Previous Definition

Unit	**metre**
Symbol	**m**
Quantity	length
Defining Constant	speed of light
Defining Resolution	CGPM Resolution 1 (2018)
Unit Type	SI base unit
Defining Equation	$1\ \mathrm{m} = \left(\frac{c}{299\,792\,458}\right)\mathrm{s} = \frac{9\,192\,631\,770}{299\,792\,458}\,\frac{c}{\Delta\nu_{\mathrm{Cs}}} \approx 30.663\,319\,\frac{c}{\Delta\nu_{\mathrm{Cs}}}$

The SI Digital Framework provides a fully digital representation of the SI

- Providing the globally accepted anchor of trust for metrology in the digital era
- Facilitating the use of digital certificates and the adoption of the FAIR principles



14

The SI Digital Framework provides a fully digital representation of the SI

- Providing the globally accepted anchor of trust for metrology in the digital era
- Facilitating the use of digital certificates and the adoption of the FAIR principles

Services underpinning the SI digital framework

BIPM digital references

- SI Reference Point
- Measurement service categories
- Calibration and Measurement Capabilities (CMC)
- National Metrology Institutes
- Unit interoperability service

External digital references

- ROR
- ORCID
- InChI

BIPM online databases

- Key Comparison Database - B
- Key Comparison Database - C
- UTC database

All human readable, through API, and machine readable using SPARQL queries

15

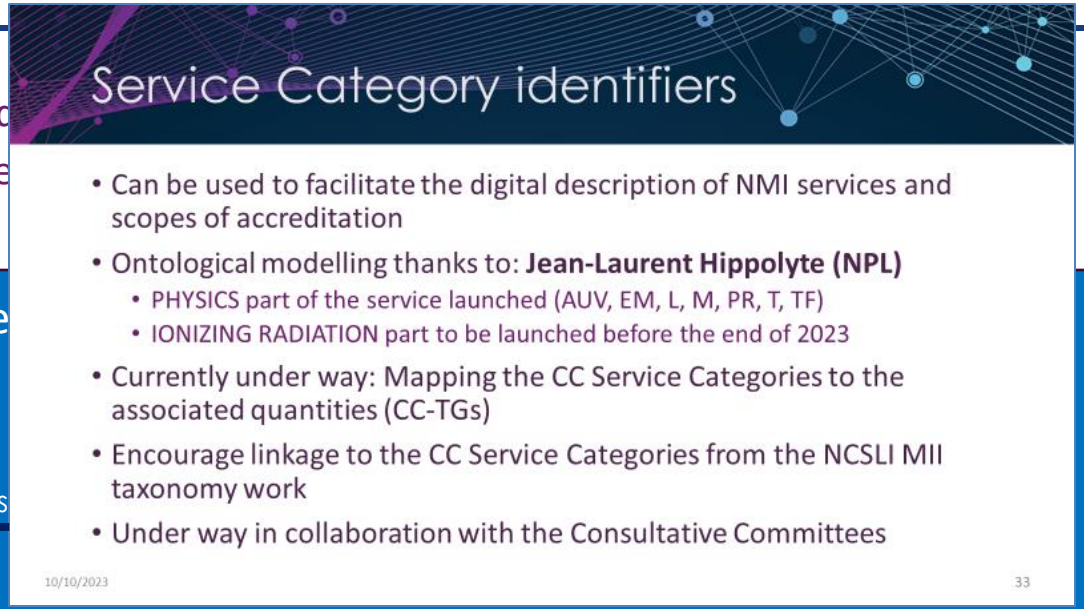
The SI Digital Framework provides a fully digital representation of the SI

- Providing the globally accepted
- Facilitating the use of digital ce

Services underpinning the

BIPM digital references

- SI Reference Point
- Measurement service categories
- Calibration and Measurement Capabilities (CMC)
- National Metrology Institutes
- Unit interoperability service

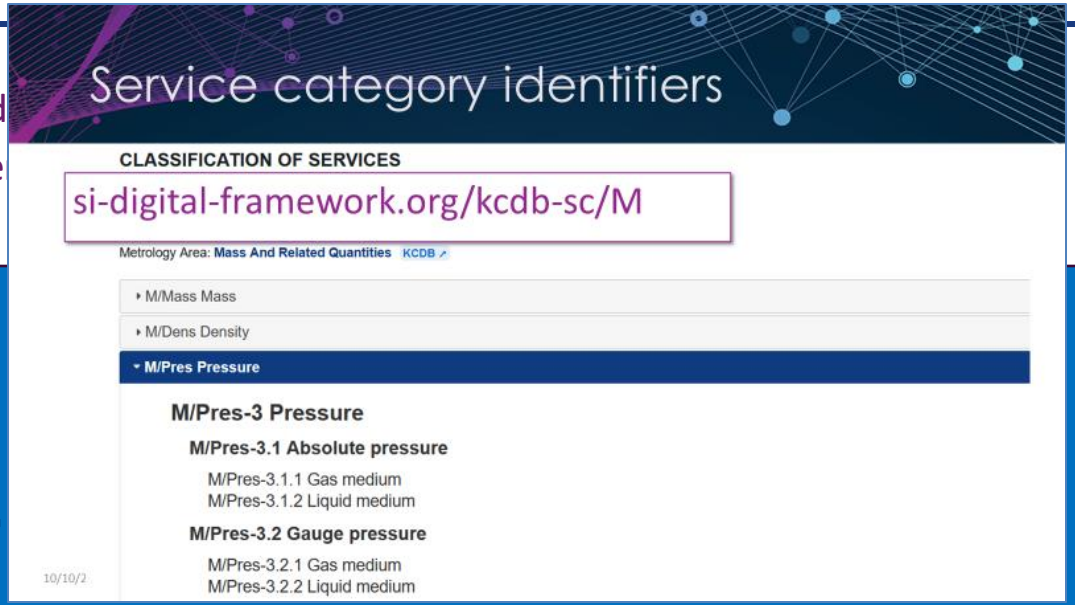


All human readable, through API, and machine readable using SPARQL queries

16

The SI Digital Framework provides a fully digital representation of the SI

- Providing the globally accepted
- Facilitating the use of digital ce



Services underpinning the BIPM digital references

- SI Reference Point
- Measurement service categories
- Calibration and Measurement Capabilities (CMC)
- National Metrology Institutes
- Unit interoperability service

All human readable, through API, and machine readable using SPARQL queries

17

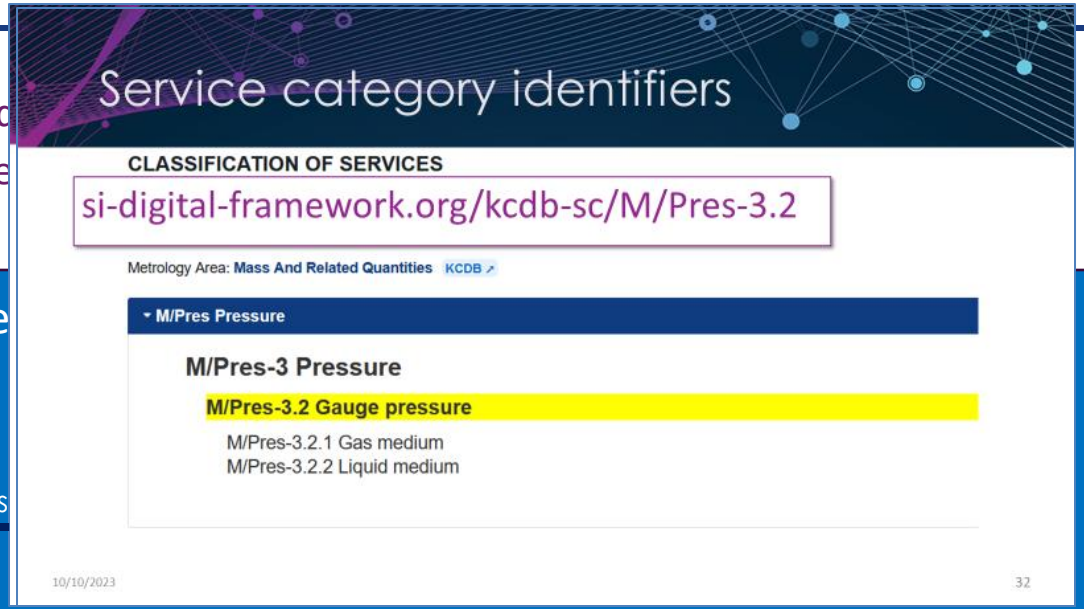
The SI Digital Framework provides a fully digital representation of the SI

- Providing the globally accepted
- Facilitating the use of digital ce

Services underpinning the

BIPM digital references

- SI Reference Point
- Measurement service categories
- Calibration and Measurement Capabilities (CMC)
- National Metrology Institutes
- Unit interoperability service



All human readable, through API, and machine readable using SPARQL queries

18

The SI Digital Framework provides a fully digital representation of the SI

- Providing the globally accepted anchor of trust for metrology in the digital era
- Facilitating the use of digital certificates and the adoption of the FAIR principles

Serv

BIPM

- SI R
- Me
- Ca Ca
- Na
- Un

KCDB-CMC Identifier: SIM-QM-CR-00000JW7-1

Published in the KCDB

Approved on 23 October 2019

KCDB Service Category: QM-5.1

Costa Rica, LACOMET (Laboratorio Costarricense de Metrologia)

Institute service identifier : 13.1.0.1.3, 32.1.0.0.1 and 34.1.0.0.1

Matrix or material	Analyte or component	Dissemination range of measurement capability		Range of certified values in reference materials	
		Mass fraction in mg/kg	Absolute expanded uncertainty in mg/kg	Mass fraction in	
natural water, synthetic water, acid solution (up 10 %)	potassium	0.14 to 1.00E4	0.011 to 147		

Mechanism for measurement service delivery : Assigning values to PT scheme samples, internal calibration

BIPM online databases

- Key Comparison Database - B
- Key Comparison Database - C
- UTC database

dable using SPARQL queries

19

The SI Digital Framework provides a fully digital representation of the SI

- Providing the globally accepted anchor of trust for metrology in the digital era
- Facilitating the use of digital certificates and the adoption of the FAIR principles

Serv

BIPM

- SI R
- Me
- Ca Ca
- Na
- Un

KCDB-CMC Identifier: SIM-QM-CR-00000JW7-1

Published in the KCDB

Approved on 23 October 2019

KCDB Service Category: QM-5.1

Costa Rica, LACOMET (Laboratorio Costarricense de Metrologia)

Institute service identifier : 13.1.0.1.3, 32.1.0.0.1 and 34.1.0.0.1

Matrix or material	Analyte or component	Dissemination range of measurement capability		Range of certified values in reference materials	
		Mass fraction in mg/kg	Absolute expanded uncertainty in mg/kg	Mass fraction in	
natural water, synthetic water, acid solution (up 10 %)	potassium	0.14 to 1.00E4	0.011 to 147		

Mechanism for measurement service delivery : Assigning values to PT scheme samples, internal calibration

dable using SPARQL queries

BIPM online databases

- Key Comparison Database - B
- Key Comparison Database - C
- UTC database

The SI Digital Framework provides a fully digital representation of the SI

- Providing the globally accepted anchor of trust for metrology in the digital era
- Facilitating the use of digital certificates and the adoption of the FAIR principles

Serv

BIPM

- SI R
- Me
- Ca Ca
- Na
- Un

KCDB-CMC Identifier: SIM-QM-CR-00000JW7-1

Published in the KCDB

Appr ved on 23 October 2019

KC B Service Category: QM-5.1

Costa Rica, LACOMET (Laboratorio Costarricense de Metrologia)

Institute service identifier : 13.1.0.1.3, 32.1.0.0.1 and 34.1.0.0.1

Matrix or material	Analyte or component	Dissemination range of measurement capability		Range of certified values in reference materials	
		Mass fraction in mg/kg	Absolute expanded uncertainty in mg/kg	Mass fraction in	
natural water, synthetic water, acid solution (up 10 %)	potassium	0.14 to 1.00E4	0.011 to 147		

Mechanism for measurement service delivery : Assigning values to PT scheme samples, internal calibration

dable using SPARQL queries

BIPM online databases

- Key Comparison Database - B
- Key Comparison Database - C
- UTC database

21

The SI Digital Framework provides a fully digital representation of the SI

- Providing the globally accepted anchor of trust for metrology in the digital era
- Facilitating the use of digital certificates and the adoption of the FAIR principles

Serv

BIPM

- SI R
- Me
- Ca Ca
- Na
- Un

KCDB-CMC Identifier: SIM-QM-CR-00000JW7-1

Published in the KCDB

Approved on 23 October 2019

KCDB Service Category: QM-5.1

Costa Rica, LACOMET (Laboratorio Costarricense de Metrología)

Institute service identifier : 13.1.0.1.3, 32.1.0.0.1 and 34.1.0.0.1

Matrix or material	Analyte or component	Dissemination range of measurement capability		Range of certified values in reference materials	
		Mass fraction in mg/kg	Absolute expanded uncertainty in mg/kg	Mass fraction in	
natural water, synthetic water, acid solution (up 10 %)	potassium	0.14 to 1.00E4	0.011 to 147		

Mechanism for measurement service delivery : Assigning values to PT scheme samples, internal calibration

BIPM online databases

- Key Comparison Database - B
- Key Comparison Database - C
- UTC database

dable using SPARQL queries

22

The SI Digital Framewo

- Providing the globally ac
- Facilitating the use of dig

- ROR: Research Organization Registry

https://ror.org

- Wikidata

https://wikidata.org

Serv

BIPM

- SI R
- Me
- Ca Ca
- Na
- Un

KCDB-CMC Identifier: SIM-

Published in the KCDB

Approved on 23 October 2019

KCDB Service Category: QM-5.1

Costa Rica, LACOMET (Laboratorio Costarricense de Metrología)

Institute service identifier : 13.1.0.1.3, 32.1.0.0.1 and 34.1.0.0.1

Matrix or material	Analyte or component	Dissemination range of measurement capability		Range of certified values in reference materials	
		Mass fraction in mg/kg	Absolute expanded uncertainty in mg/kg	Mass fraction in	
natural water, synthetic water, acid solution (up 10 %)	potassium	0.14 to 1.00E4	0.011 to 147		

Mechanism for measurement service delivery : Assigning values to PT scheme samples, internal calibration

BIPM online databases

- Key Comparison Database - B
- Key Comparison Database - C
- UTC database

dable using SPARQL queries

23

The SI Digital Framework provides a fully digital representation of the SI

- Providing the globally accepted anchor of trust for metrology in the digital era
- Facilitating the use of digital certificates and the adoption of the FAIR principles

Serv

BIPM

- SI R
- Me
- Ca Ca
- Na
- Un

KCDB-CMC Identifier: SIM-QM-CR-00000JW7-1

Published in the KCDB

Approved on 23 October 2019

KCDB Service Category: QM-5.1

Costa Rica, LACOMET (Laboratorio Costarricense de Metrologia) ROR

Institute service identifier : 13.1.0.1.3, 32.1.0.0.1 and 34.1.0.0.1

Matrix or material	Analyte or component	Dissemination range of measurement capability		Range of certified values in reference materials	
		Mass fraction in mg/kg	Absolute expanded uncertainty in mg/kg	Mass fraction in	
natural water, synthetic water, acid solution (up 10 %)	potassium	0.14 to 1.00E4	0.011 to 147		

Mechanism for measurement service delivery : Assigning values to PT scheme samples, internal calibration

BIPM online databases

- Key Comparison Database - B
- Key Comparison Database - C
- UTC database

dable using SPARQL queries

24

The SI Digital Framework provides a fully digital representation of the SI

- Providing the globally accepted anchor of trust for metrology in the digital era
- Facilitating the use of digital certificates and the adoption of the FAIR principles

Serv

BIPM

- SI R
- Me
- Ca Ca
- Na
- Un

KCDB-CMC Identifier: SIM-QM-CR-00000JW7-1

Published in the KCDB

Approved on 23 October 2019

KCDB Service Category: QM-5.1

Costa Rica, LACOMET (Laboratorio Costarricense de Metrologia)

Institute service identifier : 13.1.0.1.3, 32.1.0.0.1 and 34.1.0.0.1

Matrix or material	Analyte or component	Dissemination range of measurement capability		Range of certified values in reference materials	
		Mass fraction in mg/kg	Absolute expanded uncertainty in mg/kg	Mass fraction in	
natural water, synthetic water, acid solution (up 10 %)	potassium	0.14 to 1.00E4	0.011 to 147		

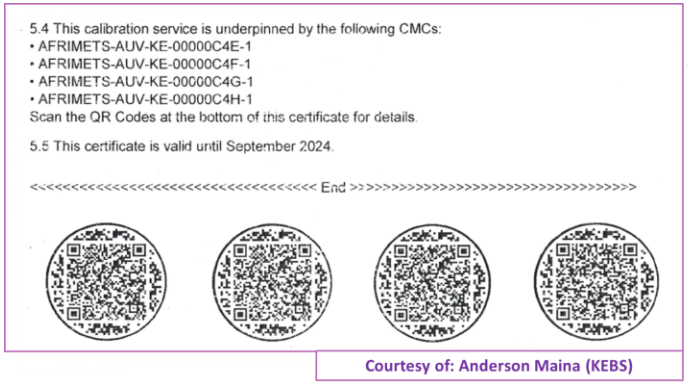
Mechanism for measurement service delivery : Assigning values to PT scheme samples, internal calibration

BIPM online databases

- Key Comparison Database - B
- Key Comparison Database - C
- UTC database

dable using SPARQL queries

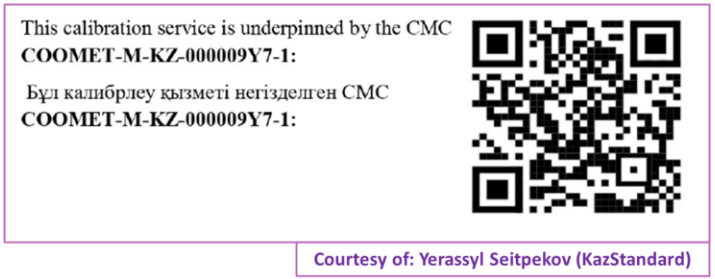
25


5.4 This calibration service is underpinned by the following CMCs:
• AFRIMETS-AUV-KE-00000C4E-1
• AFRIMETS-AUV-KE-00000C4F-1
• AFRIMETS-AUV-KE-00000C4G-1
• AFRIMETS-AUV-KE-00000C4H-1
Scan the QR Codes at the bottom of this certificate for details.

5.5 This certificate is valid until September 2024.

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<< End >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>

Courtesy of: Anderson Maina (KEBS)


This calibration service is underpinned by the CMC
COOMET-M-KZ-000009Y7-1:

Бұл калибрлеу қызметі негізделген CMC
COOMET-M-KZ-000009Y7-1:

Courtesy of: Yerassyl Seitpekov (KazStandard)

Services underpinning the SI digital framework

BIPM digital references

- SI Reference Point
- Measurement service categories
- Calibration and Measurement Capabilities (CMC)
- National Metrology Institutes
- Unit interoperability service

External digital references

- ROR
- ORCID
- InChI

BIPM online databases

- Key Comparison Database - B
- Key Comparison Database - C
- UTC database

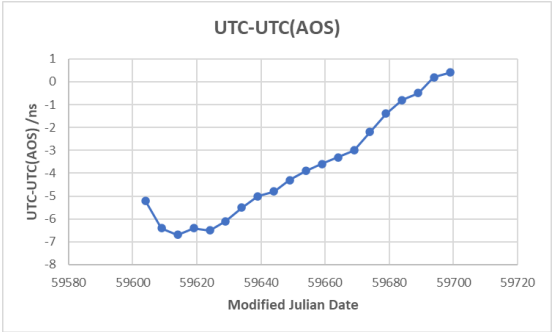
All human readable, through API, and machine readable using SPARQL queries

26

The SI Digital Framework – actions by the Consultative Committees

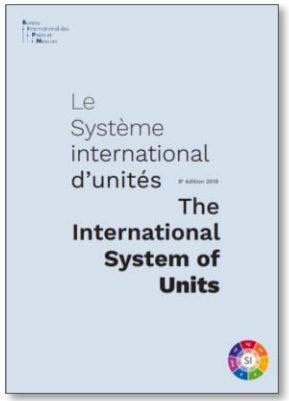
The SI-digital framework provides the basis for new Digital Transformation actions in the CCs. Examples:

CCL/CCTF	database for wavelength and frequency standards for the Mise en Pratique of the meter and the second with API access
CCTF	demonstration API to allow UTC labs to access Time Dept database directly
CCRI	digital comparison report formats
CCQM	FAIR data workshop
..	
..	



At the BIPM we are -

- supporting open data practices by providing digital reference points and machine-accessible data,
- providing the anchor of trust for metrology data.



KCDB

JCTLM
Accurate results
for patient care

IMRR

The development of the SI Digital Framework has been a collaborative effort.

Many thanks to:

- Prof Joachim Ullrich (CIPM Lead)
- The CIPM Expert Group
- NMI Partners (PTB, NIST, NPL, METAS)
- BIPM colleagues coordinated by Dr Janet Miles
- QI partners collaborating on the SI Reference Point

The CIPM Expert Group

Daniel Hutzschenreuter	PTB, DE
Peter Blattner	METAS, CH
Stuart Chalk	U. Nth FL, US
Diego Coppa	INTI, AR
Romain Coulon	BIPM, FR
Gregor Dudle	METAS, CH
Francisco Flamenco	CENAM, MX
Alistair Forbes	NPL, UK
Blair Hall	MSL, NZ
Robert Hanisch	NIST, US
Kazu Hosaka	NMIJ/AIST, JP
Chu-Shik Kang	KRISS, KR
Janet Miles	BIPM, FR
Jeon-Seon Park	KRISS, KR
Susanne Picard	BIPM, FR
Ryan White	NRC, CA
Louise Wright	NPL, UK

"thank you"

Bureau International des Poids et Mesures

Digital Reference Point SI bipm.org/digital-transformation